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COAST SURVEY.

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COAST SURVEY.

Our readers who are in the habit of perusing the proceedings of congress, must have seen frequent notices of the important work now in progress in our country, called the Coast Survey. Yet from the tenor of the frequent inquiries we have heard in reference to this work, we are led to believe that there exists in the public mind generally no very definite idea of its nature and importance. We have therefore thought that a few pages of our review devoted to a popular exposition of the objects, the method of operation, and the history of the survey, would not be uninteresting to our readers; and perhaps be of some service in the way of enlisting public opinion more generally in favour of the work, and of a liberal appropriation of means for its proper and speedy completion.

The principal object of the coast survey is the formation of an accurate map of the outline of our extended seaboard, from its northern extremity in the state of Maine, to the limits of our possessions on the Gulf of Mexico; giving the latitude and longitude of the principal points, a minute delineation of the line of the shore, a sketch of the topography of a slip of country parallel to the coast, an exact representation of the form of the bottom of the sea, within the space limited by the depth accessible to the ordinary sounding-line, the nature of the bottom, whether of clay, sand, or gravel, the position of bars, channels, and harbours, the direction and velocity of currents, the depth and temperature of the water, the bearing of the magnetic needle, and all other particulars immediately connected with the wants and improvement of navigation. In the accurate determination of these points of immediate practical utility, a number of results in the highest degree interest-

* 1. Principal Documents relating to the Survey of the Coast of the United States since 1816. Published by F. R. Hassler, Superintendent of the Survey. Two vols. 8vo. New York, 1834.

2. Executive Congressional Documents since 1832.

3. First report of Professor A. D. Bache, Superintendent of the Coast Survey, showing the Progress of the Work during the year ending November, 1844.

ing to science will also be obtained: such as new data for calculating the form and magnitude of the earth; the variation of terrestrial gravity; additions to our knowledge of the phenomena of terrestrial magnetism, and other facts of a purely scientific nature, which are regarded with the highest interest by the learned, in every part of the world.

The importance of such a survey must be evident to every one who reflects on the nature of the art of navigation, and its connexion with the commerce, and consequently with the prosperity of our nation. It is not, however, a work in which this country is alone interested, but one which affects the whole civilized world. It is a duty which every nation owes to every other, and to humanity in general, to furnish the mariner with an authentic delineation of its coast. The dangers which threaten the sailor in the midst of the wide ocean, are nothing in comparison with those which beset him as he approaches the land. With 'a sea-worthy' vessel, and a wide space for unobstructed motion, he can laugh at the winds and the waves even in their greatest power; for these, however formidable they may appear to the inexperienced landsman, are formed of yielding materials, and usually spend their force in merely changing the direction of the vessel, or in urging it more rapidly on its way; but the mere suspicion of a sunken rock, the position of which is not precisely known; or the unexpected appearance of a breaker, is sufficient to strike with terror the mariner who would brave unflinchingly the lightning and the tempest. The alternatives of life and death, of wealth and poverty, are almost every day unavoidably staked by some one on his precise knowledge of the position of a head-land, a sand-bank, or the true direction of the needle; and culpable must that nation be in the eyes of the world, who boasts of civilization, and yet does not furnish the data for an accurate knowledge of this kind.

According to the statement of a journal of the day, the truth of which we have no reason to doubt, two hundred and eighty vessels were wrecked during the last year on our coast, in which one hundred and eighty lives were lost, together with an immense amount of valuable property. Several of these vessels were, without doubt, strangers from foreign countries, allured to their destruction by the false representations of existing maps. The sailor, in his approach to our coast, has hitherto been obliged to depend on the imperfect charts founded on the surveys of the British government while we were a colony, with the exception of the local charts furnished by the energy and enterprise of Messrs. Blunt of New York, and

the surveys of particular places by the United States' corps of engineers. The consequence to ourselves of any unnecessary delay in completing the coast survey, must be to deprive us for the time, of a knowledge of the important points of our sea-board for the establishment of new harbours, roads and channels, of the means of improving our state of defence in time of war, and of lessening the risk of the lives and property of those of our citizens engaged in commerce ; as well as to degrade our national character in the estimation of all civilized nations.

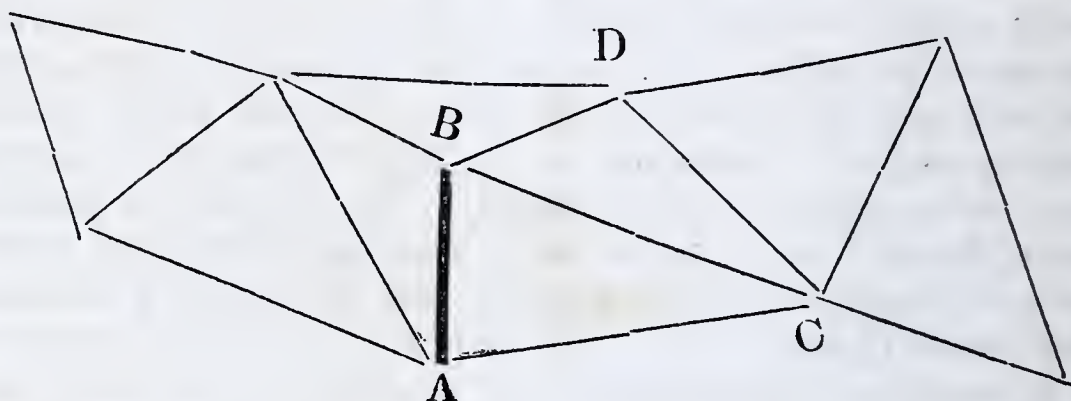
The importance and necessity of an accurate knowledge of all the particulars we have mentioned, as the principal objects of the coast survey, will be evident from a brief account of the method employed by the mariner in his approach to the land. When the weather will permit, he determines his latitude and longitude by celestial observation ; from a knowledge of these, he marks his position on the chart, and from this ascertains the course and distance of his destined port, with a knowledge of all the shoals, currents, and obstructions of every kind which may lie in his way. Or if, as is often the case, in approaching land, the sky has been obscured for several days, and the anxious sailor is uncertain as to his "reckoning," he must then have recourse to soundings. The number of fathoms of the line, and the kind of soil, whether sand, clay, gravel, &c., which adheres to the greased end of the deep sea-lead, being found to agree with the indications of a definite spot on the map, this is adopted as the position of the ship, and from it the bearing and distance of the yet unseen land is determined. Now, if the chart be incorrect with regard to the relative position of the several places, the variation of the needle, the situation of bars, &c., or, in reference to the nature and depth of the bottom, dangers of the most imminent kind will await him. A national coast survey must therefore be as accurate as the existing state of science and the arts will permit it to be. An incorrect chart, published under national authority, may in many cases be worse than useless, since it may tend to inspire confidence of safety, and thus serve to repress the vigilance of the mariner, while he is surrounded with danger.

The ordinary methods of land surveying, are entirely inapplicable to a work of this kind. It is impossible to combine together the results of the partial surveys of small districts so as to produce an uniform and consistent whole. The length of a line of forty or fifty miles, extending from one jutting point to another, across the water, is often required within a limit of error which does not exceed a few feet, or perhaps

inches; and the position of points must be determined at the distance of many miles from land, to serve as the bases of the sounding operations. The only method which can be employed to obtain accurate results of this kind, is one in which lines and angles are measured by means of trigonometry, combined with astronomical observations at the more important points. This method constitutes a branch of physico-mathematical science, to which the name of geodesy has been applied. Its origin is to be referred to the attempts of the astronomers of Alexandria, to determine the form and dimensions of the earth; but it has only been brought to any degree of perfection since the middle of the last century, by the labours principally of the English and French surveyors.

The general principles of this method of surveying, will be readily understood by a reference to the annexed diagram.

1. In a convenient level place, a line, represented by



AB, of several miles in length, is accurately measured. This line, which is the foundation of all the subsequent operations, is called the *base line*. Starting from it on either side, the surface of the country is divided into triangles, by erecting signals on elevated points, properly chosen, until the whole length and breadth of the space to be surveyed is covered with a network of triangles. The angles of these triangles being measured, the several sides can all be accurately deduced by calculation from the measured base. For example, the angles at the points A, B, C, being known, and the base AB measured, the sides AC and AB can be calculated by a simple rule of trigonometry. Again, the angles of the triangle CDB being measured, and the side CB being known from the last operation, the remaining sides CD and DB can be readily determined; and in like manner, the length of the several sides throughout the whole series, may be obtained. A system of triangles thus connected, and of which the sides, in some cases, are more than fifty miles long, is called the *primary triangulation*. It is intended to fix, with much more accuracy than could be

attained by direct measurement, the relative position of the most important points of the survey. 2. The next step in the operation, is to divide, by a similar process, each of the larger triangles into a number of smaller ones, which may serve to determine the more important intermediate points, and form the bases of the minute survey, to which the whole surface of the country is submitted, as well as that of the bottom of the sea contiguous to the coast. This system of smaller triangles is known by the name of the *secondary triangulation*. 3. Connected with the primary triangulation, a series of astronomical observations are made for ascertaining the latitude and longitude of the principal points, the result of which may serve to check the triangulation, and establish on the chart the parallels of latitude, and meridians of longitude. Such a survey is susceptible of great accuracy, and possesses within itself the data for its own verification. First, the accuracy of the measurement of each triangle can be immediately verified by the well-known theorem of geometry, which declares that the sum of the three angles of every triangle must be equal to 180 degrees; and secondly, the lines, and indeed the whole operation, can be verified by measuring one side of a triangle in a distant part of the survey, and comparing the result thus obtained, with the length deduced by computation from the original base. If the two agree within a few inches, the work is considered correct.

It might appear, at first sight, that the process here described, is one of no great difficulty of execution, and that it could be safely intrusted to men of ordinary scientific acquirements. Indeed, such an opinion has been expressed in congress: but nothing can be further from the truth; and any line of policy in reference to the coast survey, founded on this opinion, would be attended with the most disastrous consequences to the success of the work. Every error of measurement or of observation, every fault of calculation or omission of circumstances, is increased and multiplied as the survey is extended, until they amount to discrepancies utterly inadmissible in an operation of this kind. To insure, therefore, the requisite degree of accuracy, all the resources of physical science, and all the appliances of the mechanic arts, must be brought into requisition to meet the difficulties which present themselves from time to time, under the constantly varying circumstances. The truth of these remarks will be evident from a more minute examination of some of the processes of the survey.

To measure a base line, may appear a simple and easy op-

eration ; and this is the case where no minute degree of accuracy is required, and when the line is of no considerable length : but in a large survey it forms, perhaps, the most tedious part of the work, and under the most favourable circumstances, presents difficulties which never fail to call forth the scientific resources and inventive powers of the operator. Although a bar of metal at rest on the ground, may appear to have a fixed and unalterable length, yet we find, on examination, that it is almost constantly in a state of change, expanding or contracting continually with the varying temperature of the day and the season. A line of six miles in length, measured in mid-winter, with an iron rod, would appear about eighteen feet shorter, if measured again during a warm day in summer, with the same instrument : the temperature of the measuring rods must therefore be carefully noted, and the expansions and contractions allowed for. In the measurement of the base, near London, for the trigonometrical survey of England, deal rods were at first used ; and although these were made of well seasoned timber, and carefully varnished, yet the changes in their length, produced by the moisture and dryness of the air, were so considerable, that all confidence in the results deduced from them was taken away. Glass rods of twenty feet in length, and supported in wooden frames, were afterwards substituted in the place of these. In the American survey, under the direction of Mr. Hassler, the whole measuring rod consisted of an assemblage of four iron bars, each of two *metres* (39.4 inches) in length ; these were clamped together and supported in a wooden trough, prepared for the purpose ; the bars had previously been accurately compared with a copy of the French standard, which had been obtained by Mr. Hassler, in 1799. It also requires no inconsiderable skill to place the rods in two consecutive positions in a straight line, and to make the beginning of the one exactly coincide with the ending of the other. In the French and English surveys, the latter object was attempted to be effected by the simple contact of the ends of the rod with a fixed obstacle, while in the American survey, the same object was more accurately attained by an optical contact. For this purpose, a hair was stretched across a semicircular opening at the end of the bar, and made to coincide with the image of the intersection of two lines drawn on a plate of ivory attached to a microscope, which was itself fixed for the time on a stand entirely separate from the support of the rod. The microscope remaining undisturbed, the rod was carried forward to a new position, and the hair stretched across the opening in

the hinder end made to coincide with the same point. The microscope was next moved forward and adjusted to the hair on the front end of the rod, and so on to the end of the operation. Again, the line thus measured in the most favourable position, although its parts may be in the same plane, is in reality not a straight line, but a part of a polygon described around the curvature of the earth, the sides of which are each equal to the length of the measuring rod. This polygonal line must be reduced to a continuous curve at the mean elevation of the level of the sea.

The next important point which deserves particular notice, is the establishment and mensuration of the angles of the primary triangles. In order to insure the best results, the triangles should be as nearly equilateral as the surface of the ground will admit, and the sides from twenty to thirty and even fifty miles in length. To satisfy these conditions requires a very careful exploration of the country by an experienced eye. That the precise position of the angular point may be observed at the distance mentioned, artificial signals are required and of these several different kinds have been employed. In the English survey simple masts were erected and they were found to answer very well when projected against a clear sky but when the back ground was a dark object they were not distinctly visible even when painted white. In other surveys balls elevated on the top of masts were used. In the survey of the coast of the United States, Mr. Hassler employed at first truncated cones of burnished tin which reflected an image of the sun, and being elevated on masts were seen at a great distance; but the instrument which has superseded all others for this purpose, and is now used on the coast survey, is that called the Heliotrope, the invention of Professor Gauss of Gottingen. It consists essentially of a small mirror placed immediately over the angular point and so adjusted that a beam of reflected sun light is thrown directly into the telescope of the distant observer. To keep the beam constantly in the proper direction from which it would soon be deflected by the motion of the sun, a person is employed to adjust the mirror anew, from time to time, and for the more ready effecting of this, it is attached to a telescope through which the distant station can be distinctly seen. The telescope being properly pointed, the beam of sun light is directed along a line parallel to the axis of the instrument, by means of two holes in screens attached to its side. By this arrangement, a mirror of a few inches in diameter, can be distinctly observed in a clear day at the distance of forty or fifty miles.

The measurement of the precise magnitude of the angle, included between any two sides of the large triangles, is a delicate operation for the performance of which different instruments have been employed. The first surveyors who aimed at any accuracy, used a large quadrant of a circle divided to the fraction of a minute and furnished with two telescopic sights, one of which being directed to the signal at one end of one of the lines, and the other sight to the signal at the end of the other line, the arc included between the two directions was the measure of the angle required. This instrument, simple as it may appear, is liable to be influenced by so many causes of error that the use of it has been abandoned. It is practically impossible to divide a circle into a given number of parts, all precisely equal among themselves. To obviate the errors arising from this cause, an instrument consisting of an entire circle was used in the survey on which was founded the French system of weights and measures. A repetition of the measurement of the angle being made in succession, on the different parts of the circumference of the circle, the errors of the divisions would tend to balance each other, and the average of all the measurements would be a nearer approximation to the truth. There is, however, the objection to the use of this instrument, that it merely gives the measure of the angle in the plane of the sides of the triangle, while for the purposes of the survey, the horizontal angle, or that of a spherical triangle described on the convex surface of the earth is required; consequently a reduction is to be made, founded on an additional observation of the angle of altitude of the one station above the other. In the English survey an instrument called a theodolite was employed, which differs from the repeating circle, in having the telescopic sight, moveable in a vertical plane, so that while the graduated circle is horizontal, the telescope can be directed to a point above the horizontal plane, and in this way the spherical angle can be directly obtained without subsequent calculation. In the beginning of the coast survey of the United States, the angles of the primary triangles were measured with a theodolite of two feet in diameter, but for this was afterwards substituted a more perfect instrument by Troughton and Sims, of London, which has been used with admirable success since 1836. The graduated circle of this theodolite, is thirty inches in diameter, and it is said to exceed any other instrument ever made for the same purpose, both in the size of the telescope and the power of the microscope, for reading the divisions. But no instrument constructed by human means

can be expected to be perfectly accurate. Notwithstanding all the care that may be bestowed on it by the maker, it will be found affected with errors inseparable from the very nature of the material, and, therefore, it becomes the duty of the surveyor, to adopt such methods of observation as may serve, in the greatest degree, to diminish the errors or to cause those of opposite tendencies to balance each other. It is truly surprising to what a degree of accuracy ingenuity has carried the principle of the elimination of error in works of the kind; but the proper application of this principle can only be made by one who to much experience, adds a profound knowledge of physico-mathematical science.

After the triangulation of a district has been completed, and the exact relative position of every point in the survey accurately protracted, it is next required to draw on the map the lines of relative latitude and longitude. For this purpose were the earth a perfect sphere, the bearing of any one of the principal lines with reference to the true north being obtained, that of all the other lines could be calculated and the lines of latitude and longitude for the whole chart be accurately projected; but as the earth is not perfectly spherical, this method is not to be relied on, and therefore the bearing, or the azimuth as it is called, of different lines in distant parts of the survey must be determined. The simplest method of accomplishing this is by means of the theodolite directed first along one of the lines of the survey, and then to the pole star when it is farthest east, and also when farthest to the west of the meridian. The mean angle between these directions is the quantity required. But even the frequent determination of the azimuth cannot be relied upon solely for giving the difference of longitude, especially when the survey has considerable breadth in the east and west direction. In addition to it, astronomical observations should be frequently made at fixed points, such as those of the occultation of stars by the moon, of solar eclipses, &c., which may also serve to determine the longitude from the first meridian. The employment of the magnetic telegraph also affords a ready method of ascertaining the difference of time, and hence the longitude between the several points of the survey which may happen to be near its path; and even in some cases it strikes us, a wire might be temporarily extended from one point to another for the same purpose, the return part of the circuit being formed by the ground.

In order to be constantly assured of the accuracy of the work, the tests of verification should be frequently applied.

The sum of the three angles should exhibit what is called the spherical excess; and the base of verification in measurement and computation, give the same result within a few feet, even in a length of five or six miles, and at the distance it may be of several hundred miles from the original base. Such accuracy has been obtained in the great surveys of Europe and will undoubtedly be exhibited in the American survey.

Trigonometrical surveys of the kind we have described, have been made or are now in progress in various parts of the world, namely, in Austria, Russia, Sweden, Denmark, Hanover, Prussia, Swabia, Bohemia, and the German States generally, Italy, Naples, and Sicily, Switzerland, France, England, the British possessions in India and the territory of the French colony in Algiers. Europe is indeed covered with a series of triangulations, from the south of Sicily to the polar circle, from Ireland to the interior of Russia, from Bordeaux to the frontier of Turkey. Some of these commenced in the latter part of the last century are still in progress.

The American coast survey was recommended to congress by President Jefferson, during the session of 1807, and an appropriation of \$50,000 was made for the work in February of the same year. During the following month circulars were addressed by the Secretary of the Treasury, Mr. Gallatin, to a number of scientific gentlemen, requesting their opinion individually, as to the plans to be adopted for carrying out the provisions of the law. Thirteen answers were returned to these circulars, which were submitted to a committee of the members of the American Philosophical Society, at the head of which was the president of the institution, Dr. Patterson. After a full consideration of the merits of the several plans proposed, that submitted by Mr. Hassler, a native of Switzerland, who had been employed in operations of the same kind in his own country, was adopted. The survey was however destined to meet with many delays and difficulties. On account of the threatening aspect of public affairs in reference to a rupture with Great Britain, nothing was done in the way of immediate preparation for the work until August, 1811, when Mr. Hassler was sent to England to procure the necessary apparatus for carrying into operation the plans proposed by himself; but before the instruments could be finished war was declared, and the agent was detained abroad as an alien enemy, until 1815.

In August, 1816, Mr. Hassler was formally appointed superintendent of the coast survey, and immediately entered on the duties of his office in the way of exploring the country

for the purpose of discovering a suitable position for the establishment of a base line. A locality for this essential part of the survey, was finally chosen in that part of New Jersey which borders on the Hudson, and is immediately behind the perpendicular ledge of rocks well known to the traveller on that river by the name of the Palisades. The base line was measured in the spring of 1817, and was found to be 30999.8 English feet, or a little more than five miles and a half long. During the same year, a series of triangles founded on this base and spreading over the basin of the lower part of the Hudson, including New York bay and the adjoining country, was established, in order to the extension of the survey north and south, along the sea-board. Also to be assured at the beginning of the work, of the accuracy of the instruments and methods employed, a base of verification was measured on the south shore of Long Island, near the Narrows, the length of which deduced from the triangulation, was found to agree with the actual measurement within about eight inches, the whole length of the line being $25443\frac{1}{4}$ English feet, or nearly five miles.

We might conclude from these facts that the survey had now been commenced in good earnest, and that the work would be prosecuted to a successful termination, with a liberal support from the government, but this was not destined to be the case; before Mr. Hassler could have an opportunity of presenting a report of the result of his labours during the year, the survey was effectively discontinued by an act of congress, passed in April, 1818. The principal cause of this sudden stoppage of the work is to be attributed to a want of a proper appreciation of the importance of the object, and a knowledge of the nature of the operations, combined with the embarrassed state of the public finance in consequence of the war which had just terminated.

In 1827, after a lapse of ten years, the coast survey was again called to public attention by the enlightened policy of the Hon. Samuel L. Southard, the Secretary of the Navy, who in his reports to congress repeatedly urged the necessity of resuming the survey on the original plan. Finally, after another delay, the law of 1807 was revived in July, 1832, and the President again authorized to employ such astronomers and other persons as he should deem proper for carrying on the work. In August of the same year, Mr. Hassler was reappointed to the charge of the survey, and continued in the employment until the time of his death, in November, 1843.

During the interval of the interruption of the survey, Mr.

Hassler presented a memoir on the subject to the American Philosophical Society, which was published in the transactions of this body in 1825. It contains a minute account of the plans adopted for carrying on the work, a description of the instruments he had procured for the purpose, and of the labours which had been performed in 1817. This memoir was received with much favour by competent judges abroad, and the commendation bestowed on it was of no little importance in awakening a sentiment of national pride, which had considerable influence in assisting the passage of the act authorizing the renewal of the survey in 1832.

Mr. Hassler's first report on the progress of the work, was made in 1834. Under the new organization, the primary triangulation was conducted exclusively by the superintendent. The secondary triangulations were carried on simultaneously in different districts, by three principal assistants, namely, by Mr. Ferguson, Mr. Blunt, and Captain Swift. The topographical operations, which consist in the filling up of the minute survey of the secondary triangles, was intrusted to five or six separate parties, each consisting of an assistant and five or six men. The hydrographical surveys were made by officers of the navy, detached by the executive department for the purpose. In these the sounding operations were carried on by the reciprocal observations of three observers on shore, and two on board the vessel. The position of the vessel at the points corresponding to the several soundings, was thus obtained by the measurement of five angles and two base lines. This system of operation was carried out as far as the land could be seen, or about twelve miles; beyond this, the position of the points of soundings was determined by means of celestial observations for latitude, and the indications of the chronometer for longitude.

Under this organization, the work appears to have been prosecuted up to the present time, but with very variable success. The first operations after the recommencement of the survey, was to uncover the station points of the triangulation of 1817, which had been preserved, in some cases, by truncated cones of stone-ware, sunk sufficiently below the surface of the ground; and in others, by drilling a hole of two inches in diameter into the solid rock; an accurate description of the locality having been placed on record. The new survey was at first based on the triangulation of 1817, and extended north and south from it; but in 1834, a new and much longer base was measured on that part of the south shore of Long Island, which extends along what is called Fire Island Beach, near

the light-house. The measurement was completed in forty-five days, with the apparatus before mentioned, and described in the transactions of the American Philosophical Society, and its length found to be $8\frac{3}{4}$ miles. The position of this base on the level beach, and but little above tide-water, offered unusual facilities for an operation of this kind. It presented, however, the disadvantage which results from the impossibility of permanently marking the terminations of the line, on account of the encroachments of the sea. To avoid the effect of this occurrence, which is said to have since actually taken place at one end, the base was referred, by triangulation, to two permanent and elevated points, from twelve to twenty miles inland: the distance between these is known in the reports of the survey by the name of the *mountain base*. Notwithstanding the objections which have been urged against this base, its great length, and the facilities which the position afforded for exact measurement, will perhaps more than compensate for the want of permanency in the points which mark its extremities. For should circumstances ever render it necessary to verify this base by another measurement a line applicable to the purpose, could be readily deduced from the mountain base; but from the present indications of the accuracy of the primary triangulation, such a necessity will probably never exist.

We have found considerable difficulty in ascertaining the precise state of the survey at the time of the death of Mr. Hassler, but from the examinations of a committee of congress in 1842, it appears that the primary triangulation extended from Mount Carmel, in Connecticut, to Yard's, near Philadelphia, including twenty primary stations, and covering 3,577 square miles. The secondary triangulation exceeded in extent the primary, and included the space along the coast from Narraganset bay in Rhode Island to Cape Henlopen at the mouth of Delaware bay. It covered a surface of about 11,000 square miles, while the topographical and hydrographical surveys up to the same time extended over about 4,200, and 5,600 square miles, respectively.

Although the coast survey had been apparently recommenced in 1832 under the most flattering circumstances, yet it must be confessed that during the ten years which followed, its progress was not such as the friends of the work and the public generally had reason to expect. Recalled to important duties requiring great personal exertions, and the adjustment of perplexing difficulties, at a period when most men begin to withdraw from the ordinary duties of active life, Mr. Hassler no longer pos-

essed the practical ability to carry out fully the plans devised by himself a quarter of a century before. But we desire not to dwell on this part of the history of the survey, and would rather call to public attention the great indebtedness of the work to the early labours of Mr. Hassler; and perhaps we cannot present this in language more appropriate than that of his successor, at the beginning of his first report. "The coast survey owes its present form and perhaps its existence to the zeal and scientific ability of the late superintendent, who devoted the energies of his life to it; and who but for its interruption at a period when he was in the prime of manhood, and its suspension for nearly fifteen years, might have seen its completion. The difficult task of creating resources of practical science for carrying on such a work upon a suitable scale, required no common zeal and perseverance for its accomplishment, especially at a time when our country was far from having attained her present position of scientific acquirement, and when public opinion was hardly sufficiently enlightened to see the full advantage of thoroughness in executing the work. For his successful struggle against great difficulties, his adopted country will do honour to his memory as the pioneer of a useful national undertaking."

The appointment of Alexander D. Bache, LL. D., to the office of superintendent of the coast survey, took place in December, 1843, and the acceptance of this gentleman, well known for his scientific labours in every part of the civilized world, and highly esteemed for his moral qualities by all who enjoy the pleasure of his acquaintance, was received by the friends of the survey as a guarantee that it would now be prosecuted with energy and skill to a successful termination. The appointment of Dr. Bache was urged on the President by letters from most of the men of scientific reputation in our country, and we know that it has received the approbation of some of the most distinguished cultivators of physical science in Europe. In filling an office of this kind it was gratifying to find that political considerations were entirely disregarded, and the merits and fitness of the individual alone considered.

Soon after the appointment of Dr. Bache he submitted a plan of operation for the ensuing season, which was fully approved by the Hon. John C. Spencer, Secretary of the Treasury, who during his continuance in office, exhibited the most lively interest in the coast survey, and readily lent his talents and his influence to every plan which might serve to improve its condition. The peculiar feature of the plan proposed by Dr. Bache was the immediate verification and closing of the

primary triangulation of Mr. Hassler by measuring a base line as near as possible to the southern termination of his labours. It was considered, in justice to his memory, that as little of the work of others as practicable should be included in his series previous to its verification; and it was also deemed most proper to assign this measurement to his senior assistant, James Ferguson, Esq. It was also proposed to verify the main triangulation, on Long Island Sound, by measuring a base as near as possible to its northern termination, besides extending as far as practical all parts of the survey.

The first report of Dr. Bache, exhibiting the progress of the survey during the year ending November, 1844, was presented to the senate in December of the same year. Our limits will only permit us to give a very brief account of its contents. It is the only report we have met with in searching for the materials of this article that gives a clear idea of the actual state of the survey at the time it was made, and accompanied with maps for its proper illustration. There is another peculiarity of the report which deserves notice as exhibiting a characteristic of Dr. Bache. We allude to the scrupulous care with which he gives to each assistant his due credit even in case of a mere suggestion.

The report is divided into several different sections; the first of which gives an account of the survey from Narraganset bay northward and eastward. In this quarter the primary triangulation, which is still under the immediate charge of the superintendent, has been extended across the state of Rhode Island and a part of Massachusetts. Five primary stations were occupied and angles observed from fifty-three different points of the survey. The whole number of angles measured by the superintendent during the season is 2,753, and the surface included within the triangles is about 1,100 square miles. The secondary triangulation in the same section has been extended so as to include Buzzard's bay and the greater part of the Vineyard sound. The area covered by it is 379 square miles. The work was planned and executed by assistant C. M. Eakin. The topographical operations in the same quarter, cover a total area of one hundred and forty square miles. The soundings under the directions of the naval officers, on this part of the coast have been nearly completed from Point Judith to New Bedford, inclusive.

The next division of the work extends from Narraganset bay to New York, and thence to the capes of the Delaware. The main triangulation of this section, which is connected with the primary triangulation of Mr. Hassler near Fire Island base,

was extended by one of the principal assistants, Edmund Blunt, Esq., over Long Island Sound, to Narraganset Bay. This work was not originally intended to take the place of a primary triangulation, but the care bestowed on it appeared to justify its provisional adoption as such, with the precaution of measuring at once a base near the north end for its verification. An eligible situation for a base was found on the site of the Providence and Boston railway, the road having been originally graded for two tracks, and only one having been constructed, a wide space was left on the side, which offered in one place an admirable location for the purpose, being easily connected with the triangulation, and affording a straight base of about eleven miles long. The measurement was commenced on the 11th of September, and completed on the 28th of November. The apparatus employed was the same used by Mr. Hassler, at Fire Island Beach, with some improvements by Mr. Blunt. This base is intended to close the survey made under the direction of Mr. Hassler, at the north, and to serve as a base of departure for a new primary triangulation, for the further extension of the work. The operations for deep sea-soundings, have been continued off the coast, in this district, under the charge of Commander T. R. Gedney, of the navy; and have been carried out from the land to the distance of from seventy to one hundred miles, and to a depth of more than one hundred fathoms. They now extend from beyond the eastern extremity of Long Island to the capes of the Delaware.

The next section relates to the extension of the secondary triangulation, which had previously reached southward to the mouth of the Delaware, under the care of Captain Johnstone, of the army. The party surveyed seventy-four square miles, and occupied twenty-seven stations; and also prepared the ground for the "plane-table" operations of next season. The topographical survey of the shore of the Delaware River and Bay, and also the soundings of the latter have been finished. The hydrographical operations have also been carried on southward and eastward of Cape Henlopen, to the extent of about one hundred and fifty square miles.

Another section of the report gives the operations in the Chesapeake Bay, relating to the selection and measurement of the proposed base for the southern verification of Mr. Hassler's triangulation. After considerable reconnoitering, the site of this base was finally chosen, by the superintendent, on Kent Island, in the Chesapeake, about thirty miles below Baltimore, and opposite Annapolis. It is five miles and four-tenths long,

and was measured by Mr. Ferguson, with the same apparatus employed by Mr. Hassler on the original base. Although the final verification of Mr. Hassler's survey cannot be completed until the primary triangulation is brought to this base, yet it is satisfactory to know, says Dr. Bache, that the results afforded through the secondary triangles, show a remarkable coincidence in the length of one of the sides, as computed from this base and from the original one, the difference not exceeding twenty inches in a line of twelve miles. Mr. Ferguson has also been engaged in the "reconnaissance" for continuing the primary triangulation of Mr. Hassler, so as to connect it with the base of verification; also the triangulation from the ends of the same base has been commenced; seven primary stations and one secondary, have been occupied; the area included within this triangulation is 420 square miles.

The progress already made in this work, leaves only five stations to complete the intended connexion with Kent Island base, and when this is accomplished, the surveys executed by Mr. Hassler and his assistants, will be included between two bases of verification about three hundred and thirty miles apart, between which the work will be nearly or quite complete, over an area reaching from Maryland to Massachusetts.

In addition to the work just mentioned, a secondary triangulation, near the head of the Chesapeake Bay, was commenced, which now includes twenty-nine stations, and covers ninety-five square miles. Also plane-table surveys were made on the shore of the Chesapeake, and the adjacent country, which cover upwards of eighty square miles, and hydrographical surveys were made covering an area of more than one hundred and fifty square miles.

Besides the operations we have described, others of a more miscellaneous kind have been undertaken. Explorations have been made, we believe by Mr. T. H. Gerdes, in North Carolina, Louisiana, Mississippi, and Alabama, for commencing the survey in these different states, during the next season. Astronomical observations for determining the latitude, longitude, and azimuth, have been made by the superintendents at several of the stations of the primary triangulations. A series of observations for latitude have been made at the two extremes of the main triangulation, and for azimuth, near the north end, by Mr. Blunt. Also a series of observations for the same purpose have been carried on by the assistants, near Kent Island. It is to be regretted that the astronomical instruments belonging to the survey were found defective, and that the superintendent was obliged to borrow from Columbia Col-

lege, and West Point, articles of the kind necessary to the prosecution of the work.

A series of magnetic observations on the variation, the dip, and the intensity of the needle, were made by Professor Renwick, of Columbia College, in some of the principal harbours of Long Island Sound. The most important of these elements, the variation, is required immediately, to finish a series of charts of this district, now preparing for publication. At several points, observations on the tides, the velocity and temperature of currents, the change in the position of bars, have been carried on, together with a series of observations on meteorology.

It is the settled policy of the present superintendent, to give the results of the survey to the public as soon as they are accurately prepared; and in accordance with this, four sheets of the map of New York bay and harbour have been published; and one hundred and sixty-nine copies distributed under the authority of an act of congress. It is however, a matter of mortification that a narrow-minded consideration of false economy, should have restricted the number to be distributed to three hundred. This number is insufficient to supply even the institutions in the different congressional districts, whose representatives have applied for them; leaving none to be sent to foreign governments, and literary and scientific societies at home and abroad. Provision was not even made for furnishing our own naval vessels; but we hope more liberal views have prevailed among the members of the last congress, in reference to this subject, and that ample provision has or will be made for the free distribution of these maps, and the immediate publication of all the work now finished in the office.

From the report of the superintendent, it appears that there exists a large amount of material, the accumulation of past years, in part or quite ready for publication. To withhold this unnecessarily from the public, is trifling with the lives and fortunes of our citizens, and doing violence to the commercial property of some of our most important cities. To show that we do not express ourselves too strongly on this point, we will refer to some discoveries made during the present year, which are given in the several parts of Dr. Bache's report, and exhibit in a strong light, the imperative necessity of the immediate publication of the results obtained, as well as the efficient extension of the work. At the close of a report made by Lieutenant commandant Blake, to the superintendent, are the following remarks. "I cannot forbear calling your atten-

tion to the great deficiencies in the existing charts of this dangerous section of the coast, upon which I have been employed this season. They all appear to have been founded upon surveys made before the Revolution, with some amendments and additions; but even immediately off the important port of New Bedford and Fairhaven, where nearly three hundred whale ships are owned, I found dangerous single rocks near one of the main ship channels with but five feet water on them, entirely omitted in the latest publication."

The same gentleman states that the survey of Delaware Bay shows a perfectly safe and direct channel for merchant vessels of the largest size, where no channel has heretofore been supposed to exist. It presents several advantages over the old channel, and must be of great importance to the commerce of Philadelphia; also three new channels have been discovered over the "Cape May ridges," which will be of great utility in the coal trade of the same city: and a dangerous shoal, hitherto known to but few, if any, of the pilots, near the main ship channel, has been traced out in the same district. The charts of Delaware Bay have been found entirely unworthy of confidence. The position assigned by the most authentic of them to one of the principal lighthouses, is nearly seven miles in error. Several dangerous shoals, with but a few feet of water upon them, and on which numerous wrecks have occurred, are placed from three to five miles from their true position; and the bay is represented in one part as fifteen miles in width, when it is actually found by the survey to be but seven.

It is expedient and proper, in all cases, to give the coast survey all the advantages of popularity which discoveries of the kind just mentioned entitle it to, and in accordance with this view, but without wishing to diminish, in the least degree, the well-merited reputation of the officers who may be engaged in the sounding operations, we must, in this place, express our decided disapprobation of the name given the new channel into the harbour of New York. Thousands who have heard of the Gedney channel, are unacquainted with the fact, that it is one of the legitimate offsprings of the coast survey, and that all engaged in the work, were concerned in the discovery. The name of Coast Survey Channel, would be, in our opinion, a more appropriate title.

From the account we have given of the report of the superintendent, it must be evident that more work has been performed during the past year, than in any previous year of the history of the survey, and this will appear more worthy of

notice, when the difficulties are considered, with which Dr. Bache had to contend, in entering on the duties of his office. The records of the labours of his predecessor, were to be deciphered, accounts were to be adjusted with the treasury department, which had been a perpetual source of perplexity to almost every secretary ; prejudices in favour of old plans, and against the introduction of new ones, were to be overcome ; and in short, almost an entirely new and more efficient organization was required, with a set of instructions for carrying it into operation during the coming year.

One of the plans adopted by Dr. Bache, we cannot speak of but in terms of the highest commendation. We allude to the apportioning of the work of calculation, and of verification, as well as of celestial observations, at certain points, among a number of the most distinguished practical astronomers of our country. By this arrangement, science will be encouraged and the interests of the survey advanced. Those who have heretofore devoted themselves to the acquisition of knowledge for its own sake, will receive a new stimulus in the moderate compensation allowed for their labours, as well as in the honour of participating in a national work of this kind. The cost of the survey will be diminished, on account of the smaller amount of pay required by a person who remains at home, and devotes but a part of his time to the employment ; and it will also be more rapidly advanced, as well as additional security offered against error, by a greater division of labour, while the principal officers of the survey, released from the labours of calculation, can devote themselves, even in winter, to the field operations of the southern triangulations. To insure the full advantages of this plan, a rule should be established, that no person be thus employed, whose reputation does not rest on actual contributions to astronomical science, which have received the commendation of competent judges. The effect of this rule, would be to exclude a host of pretenders, and place in merited relief those on whose labours the scientific character of our country, in this line, really depends.

In accordance with this plan, which received the approbation of the Secretary of the Treasury, W. C. Bond, Esq., was engaged to make a series of astronomical observations at Cambridge, and Professor E. O. Kendall at Philadelphia. Sears C. Walker, well known for his attainments in practical astronomy, is engaged in the reduction of astronomical observations. His report shows that considerable progress has already been made in the work committed to him ; five out of

nine classes of astronomical phenomena brought to bear upon the longitude of a central point of the survey, and embracing the results of seventy-two different observations, are completed. Mr. Bond has reported the result of a series of occultations and moon-culminating stars; and Mr. Kendall has already furnished interesting approximate results obtained with an Ertel circle for latitude. Professor Pierce, of Harvard University has been employed in determining the longitude approximately, between Liverpool and Boston, by the repeated exchange of chronometers, through the means of the steam packets. Also, as the beginning of a system of verification of the astronomical observations made by the officers of the survey, those of Mr. Blunt near the southern termination of his triangulation in Brooklyn, have been calculated by Professor S. Alexander, of Princeton, and observations of the superintendent are now in the hands of the same gentleman, to be submitted to the same ordeal. The valuable labours of Professor Renwick, which may be considered as belonging to the same organization, have been already mentioned; and from the whole results of the last year in reference to this plan, there can be no doubt of its importance to the work, and its beneficial effects on the science of the country.

It would also appear to be another favourite measure of Dr. Bache, to enlist in the cause of the coast survey, the talents and the influence of the officers of the army and navy, as well as to employ the recent graduates of West Point; the work offering to the latter an admirable school of practice. It is gratifying to learn that under the new organization, the gentlemen connected with these departments have shown a desire to engage in the work, and we cannot but hope soon to see the survey, with a more liberal appropriation, carried forward with increasing energy, under the generous rivalry of a number of additional parties, filled with gentlemen from these sources.

The concluding part of the report gives a statement of the intended operations of the next year, and also an estimate of the expense of the work with the same organization as last year. This amounts to eighty-eight thousand dollars for expense of the survey, and twelve thousand dollars for the publication of the work of past years. "With this appropriation," says Dr. Bache, "which does not exceed that of recent years, I feel confident that the work marked out in the foregoing report may be accomplished, the field and water operations carried on in the eastern, middle and southern sections of the work; and the speedy publication of the results be se-

cured.” “While I thus submit an estimate, grounded upon the past policy of the executive and congress, in reference to the progress of the survey of the coast I would be wanting in my duty, did I not show how the work might be more rapidly advanced. I feel the more obliged to make this statement, because selfish motives might be supposed to prompt me as superintendent of the work to desire a continuance rather than its completion.” An account is then given in detail of the plan, by which the immediate benefits of the survey may be extended in a comparatively short time, to nearly every part of our coast, by an appropriation of not more than fifty per cent. greater than that required by the present plan, while, in the sequel, the whole cost of the survey will not be increased, but rather diminished, since the operations recommended form an essential part of the survey, the expense of which cannot be lessened by any postponement; while with a more expanded scale of work, arrangements of the parties in reference to division of labour, and economy of time, become practicable, which cannot now be effected. “More than once,” says the superintendent, “have I had occasion to regret the unavoidable diminution in the efficiency of a party, by the necessary decrease in its expenditures; and I am satisfied that true economy in the yielding of results proportionate to means expended, would be consulted, by a more liberal scale of appropriation.